

FORM PTO-1390 REV. 5-93		US DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEYS DOCKET NUMBER <b>P00,1844</b>
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371			U.S. APPLICATION NO. (if known, see 37 CFR 1.5) <b>09/673961</b>
INTERNATIONAL APPLICATION NO. <b>PCT/DE99/01201</b>	INTERNATIONAL FILING DATE <b>04 November 1999</b>	PRIORITY DATE CLAIMED <b>24 April 1998</b>	
TITLE OF INVENTION  <b>GAS SENSOR AND THE USE THEREOF</b>			
APPLICANT(S) FOR DO/EO/US <b>ANDREAS BAUSEWEIN, ERIC CHEMISKY, HANS MEIXNER, BERTRAND LEMIRE and WILLIBALD SCHUERZ</b>			
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:			
<ol style="list-style-type: none"> <li>1. <input checked="" type="checkbox"/> This is a <b>FIRST</b> submission of items concerning a filing under 35 U.S.C. 371.</li> <li>2. <input type="checkbox"/> This is a <b>SECOND</b> or <b>SUBSEQUENT</b> submission of items concerning a filing under 35 U.S.C. 371.</li> <li>3. <input checked="" type="checkbox"/> This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay.</li> <li>4. <input checked="" type="checkbox"/> A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.</li> <li>5. <input checked="" type="checkbox"/> A copy of International Application as filed (35 U.S.C. 371(c)(2)) - drawings attached. <ol style="list-style-type: none"> <li>a. <input checked="" type="checkbox"/> is transmitted herewith (required only if not transmitted by the International Bureau).</li> <li>b. <input type="checkbox"/> has been transmitted by the International Bureau.</li> <li>c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office (RO/US)</li> </ol> </li> <li>6. <input type="checkbox"/> A translation of the International Application into English (35 U.S.C. 371(c)(2) - drawings attached.</li> <li>7. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)) <ol style="list-style-type: none"> <li>a. <input type="checkbox"/> are transmitted herewith (required only if not transmitted by the International Bureau).</li> <li>b. <input type="checkbox"/> have been transmitted by the International Bureau.</li> <li>c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired.</li> <li>d. <input type="checkbox"/> have not been made and will not be made.</li> </ol> </li> <li>8. <input type="checkbox"/> A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).</li> <li>9. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).</li> <li>10. <input type="checkbox"/> A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).</li> </ol>			
Items 11. to 16. below concern other document(s) or information included:			
<ol style="list-style-type: none"> <li>11. <input type="checkbox"/> An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98; (PTO 1449, Prior Art, Search Report).</li> <li>12. <input checked="" type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included.</li> <li>13. <input type="checkbox"/> A FIRST preliminary amendment. <ol style="list-style-type: none"> <li><input type="checkbox"/> A SECOND or SUBSEQUENT preliminary amendment.</li> </ol> </li> <li>14. <input type="checkbox"/> A substitute specification.</li> <li>15. <input type="checkbox"/> A change of power of attorney and/or address letter.</li> <li>16. <input checked="" type="checkbox"/> Other items or information: <ol style="list-style-type: none"> <li>a. <input type="checkbox"/> Submission of Drawings -</li> <li>B. <input checked="" type="checkbox"/> Express Mail Label EJ 07704933US</li> </ol> </li> </ol>			

U.S. APPLICATION NO. (if known, see 37 C.F.R. 1.5) <div style="font-size: 1.5em; font-weight: bold; margin-left: 100px;">09/673961</div>		INTERNATIONAL APPLICATION NO. PCT/DE99/01201		ATTORNEY'S DOCKET NUMBER P00,1844	
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17. <input checked="" type="checkbox"/> The following fees are submitted:  <b>BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5):</b> Search Report has been prepared by the EPO or JPO ..... \$860.00  International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) \$690.00  No international preliminary examination fee paid to USPTO (37 C.F.R. 1.482) but international search fee paid to USPTO (37 C.F.R. 1.445(a)(2)) ..... \$760.00  Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO ..... \$1000.00  International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) ..... \$100.00  <div style="text-align: right;"><b>ENTER APPROPRIATE BASIC FEE AMOUNT =</b></div>				CALCULATIONS		PTO USE ONLY	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)).				\$			
Claims	Number Filed	Number Extra	Rate				
Total Claims	10 - 20 =		X \$18.00	\$ 00			
Independent Claims	01 - 3 =		X \$ 78.00	\$ 00			
Multiple Dependent Claims			\$270.00 +	\$270.00			
<b>TOTAL OF ABOVE CALCULATIONS =</b>				\$1130.00			
Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be filed. (Note 37 C.F.R. 1.9, 1.27, 1.28)				\$			
<b>SUBTOTAL =</b>				\$1130.00			
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$			
<b>TOTAL NATIONAL FEE =</b>				\$1130.00			
Fee for recording the enclosed assignment (37 C.F.R. 1.21(h). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). \$40.00 per property +							
<b>TOTAL FEES ENCLOSED =</b>				\$ 1130.00			
				Amount to be refunded	\$		
				charged	\$		

a. ☒ A check in the amount of \$1130.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. \_\_\_\_\_ in the amount of \$ \_\_\_\_\_ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 501519. A duplicate copy of this sheet is enclosed.

**NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

**SEND ALL CORRESPONDENCE TO:**

**Schiff Hardin & Waite**  
**Patent Department**  
**6600 Sears Tower**  
**Chicago, Illinois 60606**

SIGNATURE  
 John D. Simpson  
 NAME

19.842 (Registration No.)

09/673961

528 Rec'd PCT/PTO 24 OCT 2000

**CERTIFICATE OF MAILING BY EXPRESS MAIL**

**"Express Mail" Mailing label Number** EJ 07704933US

**Date of Deposit:** October 24, 2000

I hereby certify that this correspondence is being deposited with the United States Postal "Express Mail Post Office To Addressee" service under 37 CFR 1.10(c) on the date indicated above and is addressed to:

BOX PCT

Hon. Assistant Commissioner for Patents

Washington DC 20231

**Case Number:** P00,1844

**International Application No.** PCT/DE99/01201


**International Filing Date:** 24 April 1998

**Title:** GAS SENSOR AND THE USE THEREOF

**Applicant:** Andreas Bausewein et al

Enclosed are the following documents:

International Application as filed, drawings, attached;  
PTO 1390 in duplicate;  
Executed Declaration  
Government Filing Fee  
Postcard

  
\_\_\_\_\_  
Signature of Person mailing documents and fees

#5

- 1 -

IN THE UNITED STATES ELECTED OFFICE OF  
THE UNITED STATES PATENT AND TRADEMARK OFFICE  
UNDER THE PATENT COOPERATION TREATY - CHAPTER II

PRELIMINARY AMENDMENT

5 APPLICANTS: Andreas Baysewein, Eric Chemisky, Hans Meixner,  
Bertrand Lemire and Willibald Schürz

ATTORNEY

DOCKET NO.: P-00,1844

SERIAL NO.: 09/673,961

EXAMINER:

10 FILING DATE:

ART UNIT:

INTERNATIONAL APPLICATION NO.: PCT/DE99/01201

INTERNATIONAL FILING DATE: 12 April 1999

INVENTION: "GAS SENSOR AND THE USE THEREOF"

**BOX PCT**

15 Assistant Commissioner for Patents  
Washington, D.C. 20231

S I R:

Please amend the above-identified International Application before entry  
into the National Stage before the U.S. Patent and Trademark Office under 35 USC

20 371 as follows:

IN THE SPECIFICATION:

Page 1, line 1, please replace the lien with the following headings and title:

TITLE

"GAS SENSOR AND A METHOD OF USING THE SENSOR"

25

BACKGROUND OF THE INVENTION-

lines 3 and 4, replace "according to the preamble of claim 1" with  
--having first and second sensor regions responding to at least one reactive  
exhaust gas constituent and a catalytic agent for converting reactive exhaust  
gas constituents with a higher catalytic activity at the first sensor region--;

- 5 line 13, change "Given an" to read --An--;  
same line, change "air, it" to read --air--;  
line 14, after "then" insert --the--;  
line 15, change "1;" to read --1 and what is referred to as a--;  
same line, change "referred to" to read --obtained--; and  
10 line 22, after "given" insert --the--.

Page 2, line 3, change "whereby" to read --so that--; and

line 26, after "formation." insert the following heading:

--SUMMARY OF THE INVENTION--.

- 15 Page 3, line 1, change "the independent claims" to read --an improvement  
in a gas sensor having first and second sensor regions responding to at least one  
reactive exhaust gas constituent and having a catalytic agent for converting reactive  
exhaust gas constituents with a higher catalytic activity in said first sensor region.  
The improvement is that the first sensor region comprises pores in which traces of  
at least one catalytically active substance are present as the catalytic agent.--;

- 20 line 2, please delete this line;  
line 12, after "as" insert --the--;  
line 16, change "drawing" to read --drying--;  
line 26, after "rich" insert --mixture or setting--;  
same line, change "lean. Given and at" to read --lean mixture  
25 or setting. At the--;  
line 27, after "lean" insert --mixture--;

line 28, after "rich" insert --mixture--; and

line 29, change "such in parallel" to read --in parallel so--.

Page 4, line 19, after "with" insert --"fuzzy logic" or--.

Page 5, line 14, delete "Shown therein are:" and insert the following

5 heading:

--BRIEF DESCRIPTION OF THE DRAWINGS--;

line 15, after "Figure 1" insert --is a cross sectional view of--;

line 16, change "the curve of resistance of" to read --is a graph of  
resistance curves for--;

10 line 18, after "Figure 3" insert --is a diagrammatic view of--;

line 19, before "According" insert the following heading:

--DESCRIPTION OF THE PREFERRED EMBODIMENTS--;

line 20, change "2on" to read --2 on--; and

same line, after "region" insert --4--.

15 Page 6, line 9, change "was [sic]" to read --were--;

line 11, change "of 20 $\mu$ m thickness and 5mm X 3mm area" to read  
--with a thickness of 20 $\mu$ m and an area of 5mm by 3mm--;

same line, change "were" to read --was--;

line 28, after "rich" insert --mixture--; and

20 same line after "lean" insert --mixture--.

Page 7, lines 1 and 10, after "rich" (each occurrence) insert --mixture--;

line 4, after "lean" insert --mixture--;

line 6, before "parallel" insert --a--; and

line 7, after "as" insert --a--.

Page 8, line 23, after "rich" insert --mixture--.

Page 9, line 11, after "lean" insert --mixture--.

Page 10, line 1, change "Patent Claims" to read --WE CLAIM:--.

5       Page 12, line 1, change "Abstract" to read --ABSTRACT OF THE  
DISCLOSURE--;

          line 2, please delete this line;

          line 10, before "catalytic" insert --the--; and

          line 11, delete "Figure 2".

**IN THE CLAIMS:**

10       Claim 1, line 4, change "characterized in that" to read --the improvement  
comprising--; and

          line 5, before "catalytic" insert --the--.

Claim 2, line 1, change "the preceding claims" to read --claim 1,--.

Claim 3, line 1, change "the preceding claims" to read --claim 1--.

15       Please amend claim 4 to read as follows:

          --4. (Amended) Gas sensor according to [one of the preceding claims]  
claim 1, wherein a platinum metal is employed as the catalytically active material,  
[this being] which is produced[, in particular,] by thermolysis of a platinum-  
containing compound introduced in fluid form into the pores.--

Claim 5, line 1, change "one of the preceding claims" to read --claim 1--.

Please amend claim 6 to read as follows:

5       --6. (Amended) Gas sensor according to [one of the preceding claims]  
      claim 1, wherein the sensor region is manufactured as a semiconductor thick-film[,  
      particularly by silk-screening upon] with pore formation by silk-screening.--

Claim 7, line 1, change "one of the preceding claims" to read --claim 1--.

Claim 8, lines 1 and 2, change "one of the preceding claims with" to read  
--claim 1, which includes--.

Please cancel claim 9, without prejudice, and substitute the following claim:

10       --13. A method for the employment of a gas sensor having two resistivity  
      sensor regions for at least one reactive exhaust gas constituent and having a catalytic  
      agent for converting the reactive exhaust gas constituent with higher catalytic activity  
      at the one sensor region at a lambda probe, said method comprising the steps of  
      evaluating the sensor signals of both sensor regions with changing exhaust gas  
15       mixtures in parallel so that the overall signal change of the parallel evaluation signal  
      is dominated by changes of the first sensor signal in a first exhaust gas mixture  
      arranged and is dominated by a change in the second sensor signal and a second  
      exhaust mixture range.--

20       Please cancel claims 10 and 11, without prejudice, and substitute the  
      following claims:



--14. A method according to claim 13, wherein the two sensor signals are supplied to a logic circuit, a finding is made with the logic circuit on the basis of at least one sensor signal as to whether the exhaust gas mixture lies in a first or second exhaust gas mixture range, an output signal is outputted in response to the finding,  
5 said output signal being dependent only on the first sensor signal in the first exhaust gas mixture range and being dependent only on the second sensor signal and the second exhaust gas mixture range.--

--15. A method according to claim 14, wherein an indirect supply of sensor signals to the logic circle comprises the sensor signals being amplified.--

10 --16. A method according to claim 15, wherein the sensor signals are also digitalized.--

--17. A method according to claim 14, wherein an indirect supply of the sensor signals to the logic circle comprises the sensor signals being digitalized.--

Claim 12, line 1, change "9" to read --13--.

15

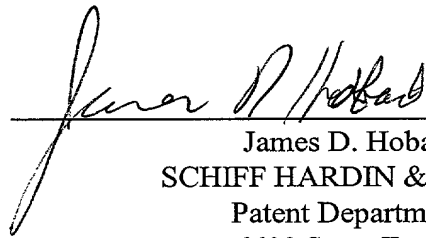
### R E M A R K S

Claims 1-8 and 12-17 are presented for examination.

By this amendment, the specification has been amended to correct typographical and grammatical errors and to supply headings. The claims have been amended to place them in form for examination in the United States Patent Office.

It is respectfully submitted that these amendments do not change the findings of the Preliminary Examination Report of July 17, 2000.

Respectfully submitted,

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DATED: December 15, 2000

IN THE UNITED STATES ELECTED OFFICE OF  
THE UNITED STATES PATENT AND TRADEMARK OFFICE  
UNDER THE PATENT COOPERATION TREATY - CHAPTER II

5	APPLICANTS:	Andreas Baysewein, Eric Chemisky, Hans Meixner, Bertrand Lemire and Willibald Schürz	
	ATTORNEY		
	DOCKET NO.:	P-00,1844	
	SERIAL NO.:	09/673,961	EXAMINER:
10	FILING DATE:	ART UNIT:	
	INTERNATIONAL APPLICATION NO.:	PCT/DE99/01201	
	INTERNATIONAL FILING DATE:	12 April 1999	
	INVENTION:	“GAS SENSOR AND THE USE THEREOF”	

15 Assistant Commissioner for Patents  
Washington, D.C. 20231

Attached herewith are two sheets of Formal Drawings containing Figs. 1-3.

20

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25

DATED: December 15, 2000

1/2

FIG 1

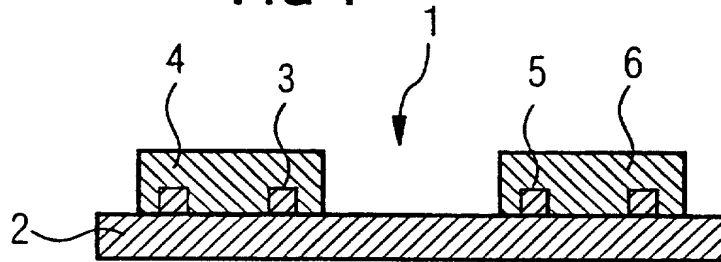
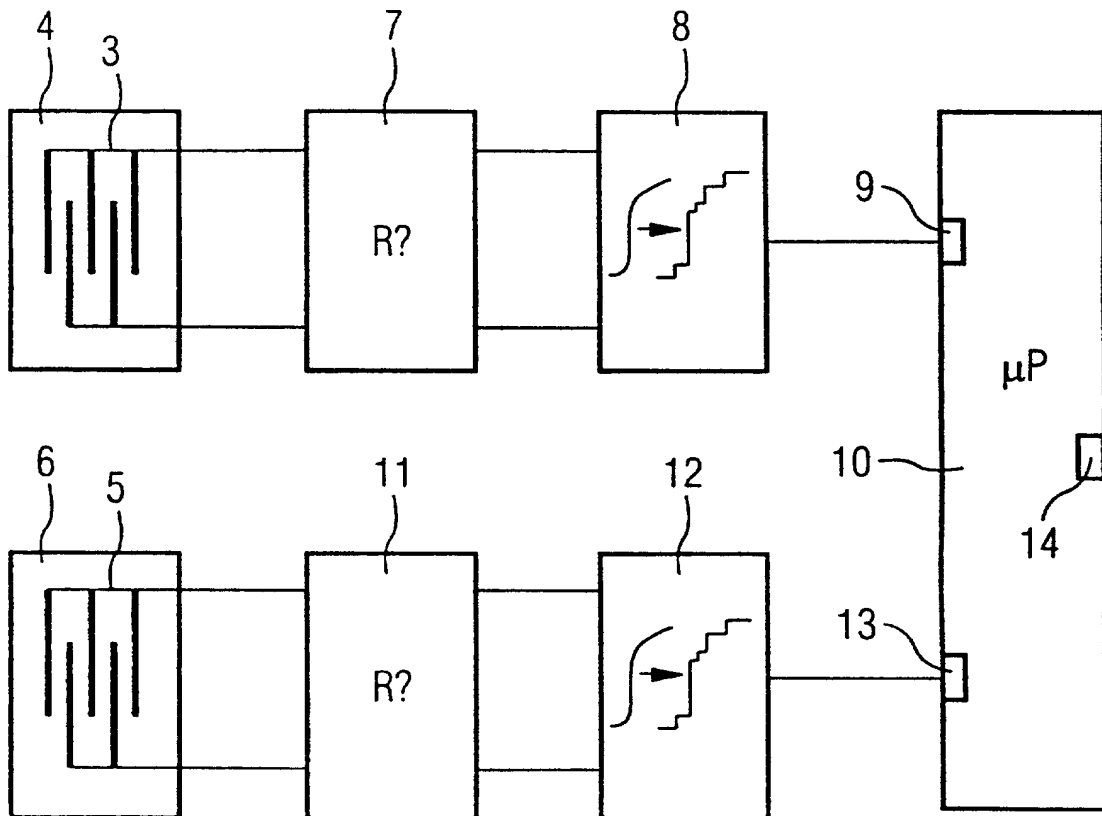
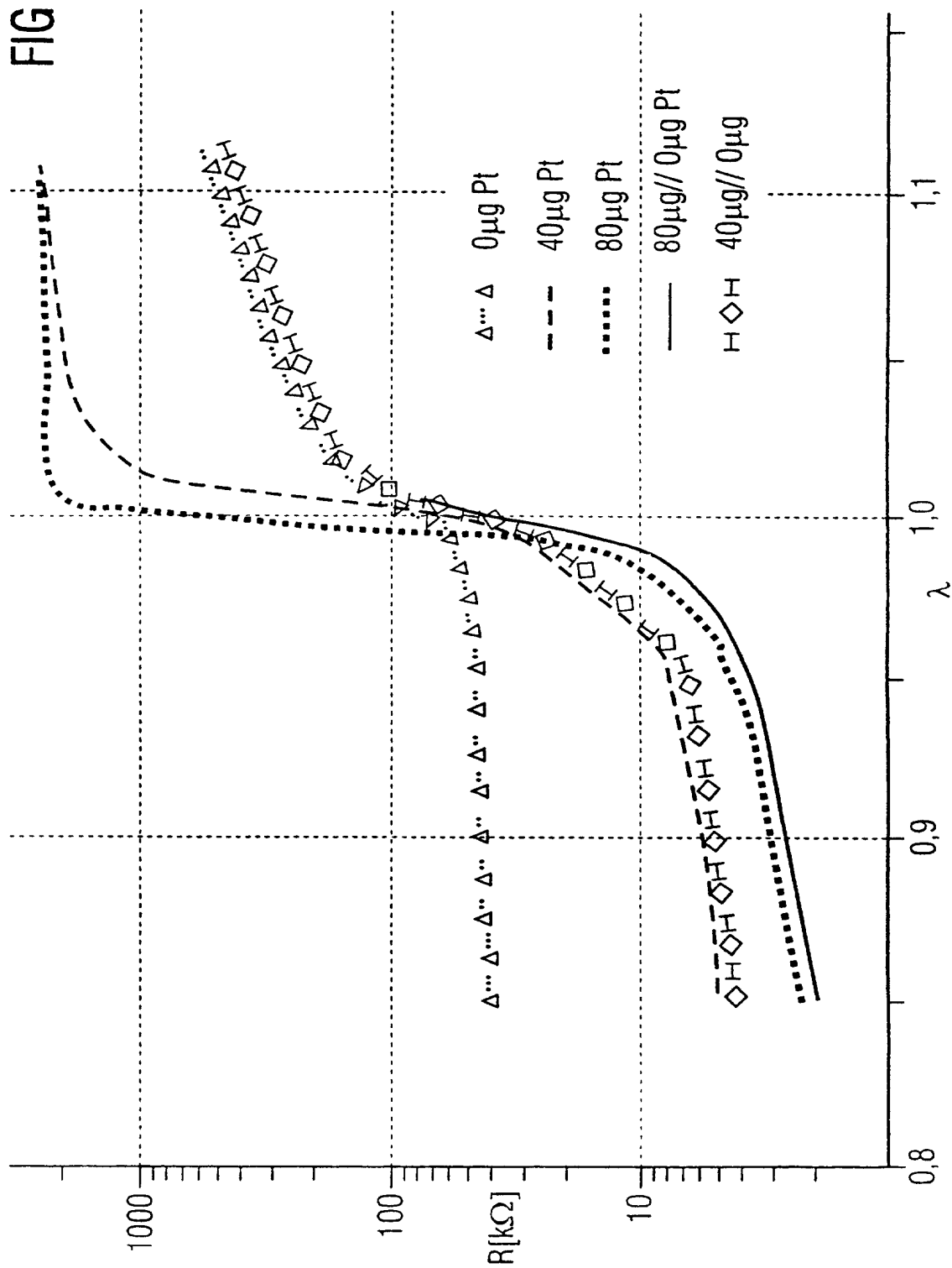


FIG 3



2/2

FIG 2



*2 p. 10*

09/673961  
10 Rec'd 11/10/00 15 DEC 2000

## GAS SENSOR AND THE USE THEREOF

The present invention is concerned with lambda probes for exhaust gas measurement and is particularly directed to a gas sensor according to the preamble of claim 1 and to a method for the employment of a gas sensor according to the preamble  
5 of the independent method claim.

Lambda probes are utilized in the automotive field in order to monitor the ratio of fuel to air, so that the fuel introduced in the motor is completely converted without excess air entering into the combustion chamber. Given an air excess, atmospheric oxygen reacts with atmospheric nitrogen in the combustion heat [sic] to  
10 form nitrogen oxides, and the pollutant emission of the motor increases. Lack of air, in contrast, leads to incomplete fuel combustion and is therefore inefficient.

One criterion for the composition of the air/fuel mixture is what is referred to as the lambda value. Given an exactly correct ratio of fuel to air, it is exactly one. When too much oxygen is introduced into the motor for a given fuel quantity, then  
15 lambda value is greater than 1; "lean operation" of the motor is referred to in view of the fuel deficiency. Here, the excess oxygen leaves the combustion chamber, and the oxygen content in the exhaust gas is high, with a partial oxygen pressure that typically lies in the percent range. When, in contrast, too little oxygen is introduced for a given fuel quantity, lambda is less than 1; this is referred to as a "rich mixture". Under these  
20 conditions, the atmospheric oxygen is practically completely converted, so that the partial oxygen pressure in the exhaust gas is several orders of magnitude lower than given lean operation.

A known arrangement for measuring the partial oxygen pressure is disclosed by DE 42 03 522 C1. It is thereby proposed to provide an O<sub>2</sub> sensor  
25 arrangement on the basis of semiconducting metal oxides whose conductivity at elevated temperature is dependent on the partial oxygen pressure, and wherein the sensor arrangement comprises two individual metal oxide sensors that, in the intended range of measurement, exhibit a different dependency of the conductivity on the partial oxygen pressure but a largely identical temperature dependency of the  
30 conductivity that is largely brought into relief in the quotient of the measured

conductivity signals of the two sensors that are formed. The sensors can thereby be selected such that their characteristics, i.e. the dependency of their conductivity on the oxygen concentration, proceed oppositely, whereby linear characteristics derive over broad ranges in double logarithmic plotting but the usual characteristic minimum can also occur. An employment of the sensor for measuring exhaust gas is not mentioned.

DE 38 33 295 A1 discloses a sensor arrangement wherein two metal oxide resistors are provided and, for temperature compensation, a shunt resistor is allocated to the one metal oxide resistor. The publication is not concerned with the catalytic activation of gas sensors.

European Patent Application EP 91 116 715 discloses an exhaust gas sensor for regulating internal combustion engines wherein a sensor unit is provided as a combination of two sensor elements that are arranged on a common substrate, whereby the one sensor element carries a catalyst layer on it and is intended to measure the partial oxygen pressure after the exhaust gas has completely reacted, for example at the sensor electrode, and whereby the other sensor element, which carries no catalyst layer, simultaneously measures the partial oxygen pressure in the exhaust gas without the catalytic setting of stoichiometric conditions, and whereby the difference signal of the signal from the one sensor element and the other sensor element is a direct measure for the incompleteness of the combustion in the internal combustion engine. The sensor elements should be identical in structure with the exception of the catalyst layer on the sensor element, and the two sensor electrode pairs are to be connected opposite one another for acquiring the difference signal. The difference circuit, however, often produces only a low output signal that, accordingly, is sensitive to interference and the like. Moreover, the signal discontinuity at the point lambda equal to 1.0 is largely suppressed by the difference formation.

A goal of the present invention is to create something new for commercial application and, particularly but not exclusively, to allow an especially precise and nonetheless fast measurement of the lambda value broad-band even given what is an unfavorable signal-to-noise ratio due to external interference.

The goal of the present invention is achieved by the independent claims, whose preferred embodiments are recited in the dependent claims.

Inventively, at least one sensor region at the gas sensor comprises pores into which a catalytically active substance is directly introduced as catalytic means.

5 Since the exhaust gases proceed immediately onto the sensor region without having to previously pass through a separate catalyst layer, the sensor, on the one hand, responds especially quickly but, on the other hand, simultaneously allows an especially precise measurement since no diffusion-inhibiting layer is present over which an oxygen gradient that falsifies the measured value could build up.

10 Especially preferably, the gas sensor is manufactured with two identical sensor regions, for instance with a silk-screening process and strontium titanate layers, whereby traces of at least one platinum metal as catalytically active material are introduced into the thick-film pores of the one sensor region formed in this way.

The platinum metal can be dribbled onto the thick-film as a fluid  
15 containing platinum metal, subsequently penetrating into the pores by capillary action. After drawing, the residue in the pores can be subjected to thermolysis. An essentially uniform activation of the sensor region over the entire layer thickness is thus achieved.

The invention also discloses a method for employing a gas sensor as  
20 lambda probe; the gas sensor comprises two resistive sensor regions that respond to at least one reactive exhaust gas constituent as well as a catalytic agent for converting the reactive exhaust gas constituent with higher catalytic activity at one sensor region. Both sensor regions discontinuously change their resistance in the region around  $\lambda=1$ . Due to the different catalytic activity, the two sensor signals, however, vary  
25 differently with  $\lambda$ : the resistance of a catalytically highly activated layer decreases monotonously toward the rich below  $\lambda=1$  but hardly changes in the lean. Given and at most less activated layer, the situation is opposite; in the lean above  $\lambda=1$ , its film resistance increases noticeably with  $\lambda$ ; however, it hardly changes in the rich. Inventively, the two different sensor signals are interpreted such in parallel that the  
30 overall signal change of the parallel evaluation signal in a first exhaust gas mixture range is dominated by changes of the first sensor signal and is dominated by changes



of the second sensor signal in a second exhaust gas mixture range. In particular, the exhaust gas mixture ranges can be a matter of the ranges above or, respectively, below  $\lambda=1$ .

5 The inventive parallel interpretation of the two sensor signals enables the desired, broadband measurement of lambda wherein it is not only the direction of the deviation from the ideal value  $\lambda=1$  but also the size thereof that can be identified. At the same time, the signal boost is always still high enough even under unfavorable conditions that the transition from the rich to the lean can be dependably recognized under all conditions.

10 A preferred parallel interpretation is based on the employment of a logic circuit to which the two sensor signals are supplied independently of one another. The logic circuit determines on the basis of at least one of the two sensor signals whether the exhaust gas mixture is in the first or second exhaust gas mixture range and outputs an output signal in response to the identified exhaust gas mixture range  
15 that is respectively dominated by one of the two sensor signals.

The logic circuit can undertake a weighting of the two signal parts varying with  $\lambda$ , whereby respectively one of the weighting coefficients strives toward one for the lean and rich, and whereby both sensor signals are identically weighted around the point  $\lambda=1$ . This can be realized with "unsharp logic".

20 The logic circuit can also work as multiplexer whose input channel selected for the through-connection is dependent on whether the signal allowed to pass at the moment represents a high or low resistance value. Optionally, a signal can also be permanently connected for interpretation to a comparator that identifies the side of the discontinuity at which the resistance value lies. The signal to be applied to  
25 the multiplexer output can be selected in response to the comparator output. The parallel interpretation, accordingly, is comprised in the forwarding of the selected signal of both signals supplied in parallel to the multiplexer.

The sensor signals need not be directly supplied to the logic circuit but can be previously edited as needed, particularly amplified and/or digitalized. The separate  
30 signal processing of the sensor signals from both sensor regions is advantageous in order to allow an optimum matching of the gain, of the input impedance, etc., to the

respective sensor layer on the basis of separate processing of the sensor signals, this improving the signal-to-noise ratio. Optionally, a multiplexer can also be arranged preceding the signal conditioning circuit for cost reasons.

Alternatively, a simple electrical parallel circuiting of the sensor signals  
 5 can ensue instead of the logic circuit. This is particularly meaningful when an economical lambda probe arrangement is desired and the values of resistance of both sensitive layers approximately correspond to one another.

Although the method is preferably implemented with a gas sensor of the present invention that is directly catalytically activated, i.e. whose sensor regions are  
 10 provided with catalytically active substance, it is likewise possible to employ a gas sensor wherein a catalytically active cover layer is simply applied on the first sensor region as catalytic agent.

The invention is described below on the basis of further exemplary embodiments with reference to the schematic drawings. Shown therein are:

- 15 Figure 1 a gas sensor of the present invention;
- Figure 2 the curve of resistance of strontium titanate layers having different catalytic activation given varying lambda value; and
- Figure 3 a sensor arrangement of the present invention.

According to Figure 1, a gas sensor 1 referenced overall as one comprises  
 20 a carrier substrate 2 on which a first sensor region of strontium titanate is applied over a first, inherently known interdigital electrode structure 3 and on which a second strontium titanate sensor region 6 is arranged over a second interdigital electrode structure 5 spatially and electrically separated from the first strontium titanate sensor region 4.

25 The carrier substrate 2 is preferably manufactured of an electrically well-insulating, inert and heat-resistant material such as aluminum oxide and comprises temperature sensors, a heating arrangement and the like as needed and is known in and of itself (not shown).

The strontium titanate regions 4 and 6 are preferably applied in thick-film  
 30 technique, for instance with silk-screening processes, as a result whereof they are porous. Both sensor regions 4 and 6 are initially identical in view of the layer

thickness and composition. In the first sensor region 4, however, traces of a catalytically active material such as titanium dioxide or platinum metal traces are introduced. The introduction of platinum metal traces can ensue in that a liquid solution of a platinum metal compound such as dissolved hexachloroplatinum acid is  
 5 dribble onto the sensor region 4, dried according to a predetermined temperature profile and the residue is then subjected to thermolysis, so that platinum metal traces deposit in the entire layer.

In a practical exemplary embodiment, a gas sensor having strontium titanate sensor regions that was [sic] applied in thick-film technology by silk-  
 10 screening is activated in the first sensor region with 80  $\mu\text{g}$  platinum given a sensor region size of 20  $\mu\text{m}$  thickness and 5 mm X 3 mm area. The 80  $\mu\text{g}$  platinum were introduced in the form of a 26% hexachloroplatinum acid solution.

The sensor region 6 is preferably free of such a catalytic activation. In this case, the catalytic agent comprises only the catalytically active substance in the first  
 15 sensor region 4. Optionally, the second sensor region 6 can likewise be provided with catalytic activation whose catalytic activity, however, is kept low by introduction of a smaller quantity of catalytically active substance. This effects a pre-aging of the sensor: by reaction of exhaust gas constituents with the layer material, catalytically active substances can form therein little by little, which would gradually modify the  
 20 response behavior of a non-activated layer; the slight activation anticipates this without disturbing the inventive effect.

According to Figure 2, a respectively clear, different resistance curve dependent on the lambda value is produced by the different catalytic activation in the two layers.

25 According to Figure 2, the resistance characteristic (shown dotted) of a strontium titanate sensor region that is already highly activated with 80  $\mu\text{g}$  platinum onto the aforementioned volume drops monotonously with decreasing lambda in the rich below  $\lambda < 1$ , whereas it is practically constant in the lean above the discontinuity region at  $\lambda > 1$ . In contrast thereto, the resistance characteristic (shown with triangles  
 30 and dots) of a sensor region without platinum activation exhibits a monotonous rise in the region of  $\lambda$  greater than 1.0, whereas its value of resistance changes practically not

at all in the rich below  $\lambda < 1$ . The influence of only a slight catalytic activation is shown with reference to the example of a layer activated with 40  $\mu\text{g}$  platinum on the indicated volume. The curve shown with broken lines still merely corresponds to the non-activated case in the lean above lambda equal to 1.

5           When the catalytically highly activated and the non-activated sensor region are connected parallel, the characteristic shown with a solid line in Figure 2 derives as parallel evaluation signal. For the evaluation of the permanently parallel-circuited arrangement, the sensor regions can be connected to a corresponding resistance measuring means. The changes in the parallel evaluation, i.e. the slope of  
10 the overall signal in the rich, practically correspond to the slope that is acquired with the sensor region 4 having catalytically highly active catalytic agent, whereas the slope of the overall signal in the lean mixing range approximately follows the curve like that covered in the sensor region 6 without catalytic activation. At the same time, the parallel evaluation signal exhibits a clearly pronounced discontinuity at  $\lambda=1$ , i.e.  
15 has a great signal boost.

The parallel circuit thus yields a monotonously changing resistance characteristic from which the size of a deviation from the rate value  $\lambda=1$  can also be identified given a varying lambda value.

Particularly when the resistance values of the layers given variation of the  
20 lambda value do not cover approximately the same resistance range, an evaluation circuit as employed in Figure 3 can further be employed for evaluation.

According to Figure 3, the resistance of the first sensor region 4 acquired via the interdigital electrode structure 3 is supplied to a resistance measuring unit 7, to a digitalization unit 8 having an analog-to-digital converter, and is then applied in  
25 digitalized form to a first input 9 of a micro-processor 10. Correspondingly, the resistance acquired via the interdigital electrode structure 5 in the second sensor region 6 is supplied to a resistance measuring unit 11 and to an analog-to-digital converter 12 whose output signal is supplied into a second input 13 of the microprocessor 10. The resistance measuring units 7 and 11 are respectively  
30 optimally designed and adapted for the measurement of the different resistance ranges of the two sensor regions.

The microprocessor 10 is programmed such that it offers a signal at its output 14 that - below a predetermined lambda value - is only dependent on the resistance of the sensor region 4 at which the catalytic agent exhibits a high catalytic activity due to the greater quantity of platinum metal traces in the sensor region. The microprocessor 10 also outputs an output signal at its output 14 in the range of lambda greater than 1 that is exclusively dependent on the resistance value at the sensor region 6 as signaled to the microprocessor 10 at the signal input 13. The signal offered at the output 14 of the microprocessor 10 can be employed for regulating the air and/or fuel delivery.

The gas sensor arrangement of the present invention is operated in the following way:

After the installation of the gas sensor arrangement in an exhaust gas channel and connection of the gas sensor to external wiring as required, particular connection of its heating structure to a voted source, its temperature sensor to a temperature measuring arrangement and wiring of the electrodes 3 and 5 to the resistance measuring unit 7 or, respectively, 11, the motor is started. During operation, for instance while the motor warms up after a cold start or given load changes, the air/fuel mixture supplied to the motor changes in terms of its composition.

For example, a change from rich to lean thereby occurs.

With a logical comparison circuit, the microprocessor 10 initially detects that the signal adjacent at its input 9 indicates a low resistance of the sensor region 4; the motor is thus being operated in the rich below the discontinuity value. In this lambda region, only the resistance characteristic of the first sensor region 4, which is provided with catalytically active platinum metal traces, exhibits a noticeable slope, in contrast whereto the resistance characteristic of the sensor region 5 proceeds largely flatly. The microprocessor 10 decides with reference to the resistance value of the characteristic measured at the region 4 that the signal obtained at the signal input 9 is applied to the output 14 as overall output signal of the gas sensor.

When the lambda range wherein the motor is operated then changes, the resistance of the sensor region 4 increases until it suddenly changes in the region of

the point lambda equal to 1.0. A rise of the resistance value above a threshold lying in the discontinuity region is thereby identified in the microprocessor 10, it thus being certain that the fuel mixture being supplied to the motor is too lean. In response to the discontinuity in resistance, the microprocessor 10 outputs the signal detected at the  
 5 input 13 and corresponding to the resistance of the sensor region 6 as output signal 14. A quantitative statement is derived from this signal in a following control regarding the extent by which the fuel mixture is too lean. Optionally, a signal processing can also ensue in the microprocessor 10, for instance in order to immediately obtain a statement about the lambda value and/or a required readjustment from the resistance  
 10 value.

When the motor is again regulated back into the lean range or proceeds there into due to a load change, this is detected at the microprocessor 10 on the basis of the signal deriving from the sensor region 6 that suddenly changes given lambda equals 1, and the signal corresponding to the resistance of the sensor region 4 is again  
 15 through-connected to the output 14. Switching is preferably carried out with hysteresis in order to suppress a tendency to hunt.

In this way, the evaluation system for two sensors is always operated on the respective branch of the respective lambda characteristic at which an especially pronounced change can be measured.

20 Whereas the present specification is directed to a sensor in thick-film technology, the inventive method can also be implemented for employment of a gas sensor with sensors that are provided with a catalytically active layer over at least one sensor region.

It is also possible to replace a logic circuit 10 that always forwards only  
 25 the signal either from the sensor region 4 or from the sensor region 6 with an arrangement that weights the signals of both sensor regions according to one or both momentary resistance values.

A structure with discrete components is also possible instead of a logic circuit with microprocessor.

**PATENT CLAIMS**

1. Gas sensor having first and second sensor regions responding to at least one reactive exhaust gas constituent and having a catalytic agent for converting reactive exhaust gas constituents with a higher catalytic activity in said first sensor  
5 region, characterized in that the first sensor region comprises pores in which traces of at least one catalytically active substance are present as catalytic agent.
2. Gas sensor according to the preceding claim wherein the second sensor region also comprises pores and the concentration of catalytically active substance is lower than in the first layer.
- 10 3. Gas sensor according to the preceding claim, wherein the concentration of catalytically active substance in the second sensor region is zero.
4. Gas sensor according to one of the preceding claims, wherein a platinum metal is employed as catalytically active material, this being produced, in  
15 particular, by thermolysis of a platinum-containing compound introduced in fluid form into the pores.
5. Gas sensor according to one of the preceding claims, wherein the sensor region is realized by a resistive semiconductor layer.
6. Gas sensor according to one of the preceding claims, wherein the  
20 sensor region is manufactured as semiconductor thick-film, particularly by silk-screening upon pore formation.
7. Gas sensor according to one of the preceding claims, wherein the sensor region is manufactured of strontium titanate.

8. Gas sensor arrangement having a gas sensor according to one of the preceding claims with a parallel evaluation circuit for parallel evaluation of the resistance values of both sensor regions.

9. Method for the employment of a gas sensor having two resistive  
5 sensor regions for at least one reactive exhaust gas constituent and having a catalytic agent for converting the reactive exhaust gas constituent with higher catalytic activity at the one sensor region at lambda probe, characterized in that the sensor signals of both sensor regions changing with the exhaust gas mixture are evaluated such in parallel that the overall signal change of the parallel evaluation signal is dominated by  
10 changes of the first sensor signal in a first exhaust gas mixture range and is dominated by changes of the second sensor signal in a second exhaust gas mixture range.

10. Method according to the preceding claim, wherein the two sensor signals are directly or indirectly supplied to a logic circuit, a finding is made with the logic circuit on the basis of at least one sensor signal as to whether the exhaust gas  
15 mixture lies in the first or second exhaust gas mixture range, and an output signal is output in response to the finding, said output signal being dependent only on the first sensor signal in the first exhaust gas mixture range and being dependent only on the second sensor signal in the second exhaust gas mixture range.

11. Method according to the preceding claim, wherein the indirect  
20 supply of the sensor signal to the logic circuit comprises that the sensor signals are amplified and/or digitalized.

12. Method according to claim 9, wherein both sensor regions are connected parallel for operation.



**Abstract****Gas Sensor And The Use Thereof**

A gas sensor is disclosed having first and second sensor regions reacting to at least one reactive exhaust gas constituent and having a catalytic agent for  
5 converting reactive exhaust gas constituents with a higher catalytic activity in the first sensor region. An especially precise and nonetheless fast measurement of the lambda value that is broadband should be allowed even given what is an unfavorable signal-to-noise ratio due to external interference. To this end, the first sensor region comprises pores in which traces of at least one catalytically active substance are  
10 present as catalytic agent.

Figure 2

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FIG 1

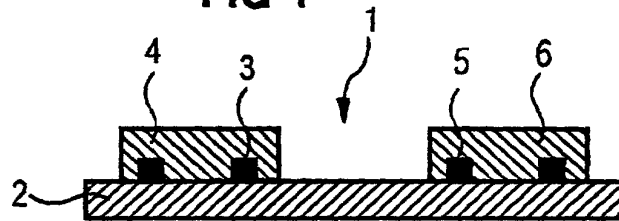
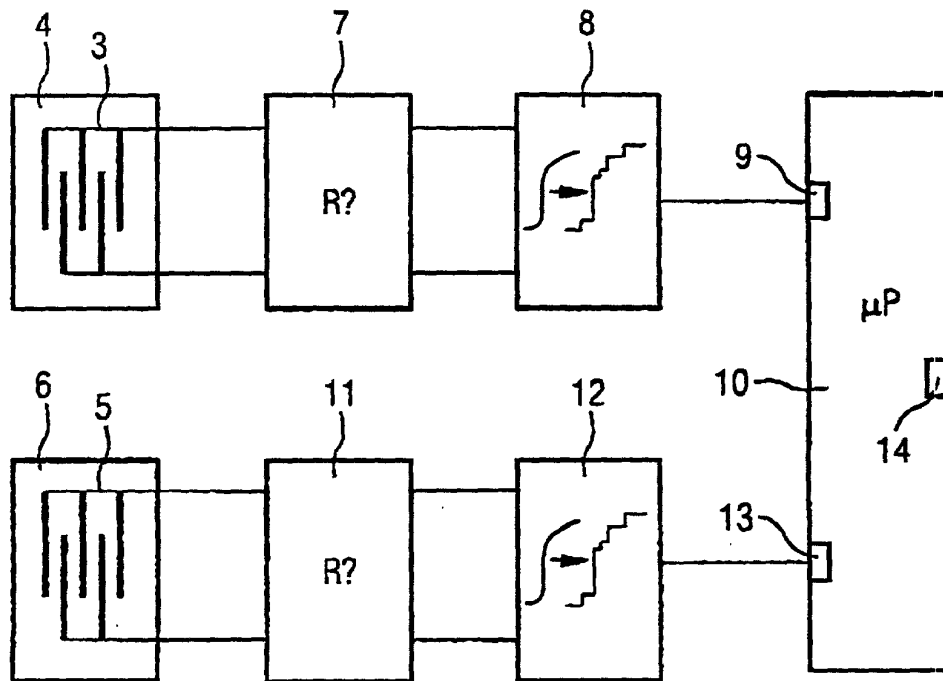
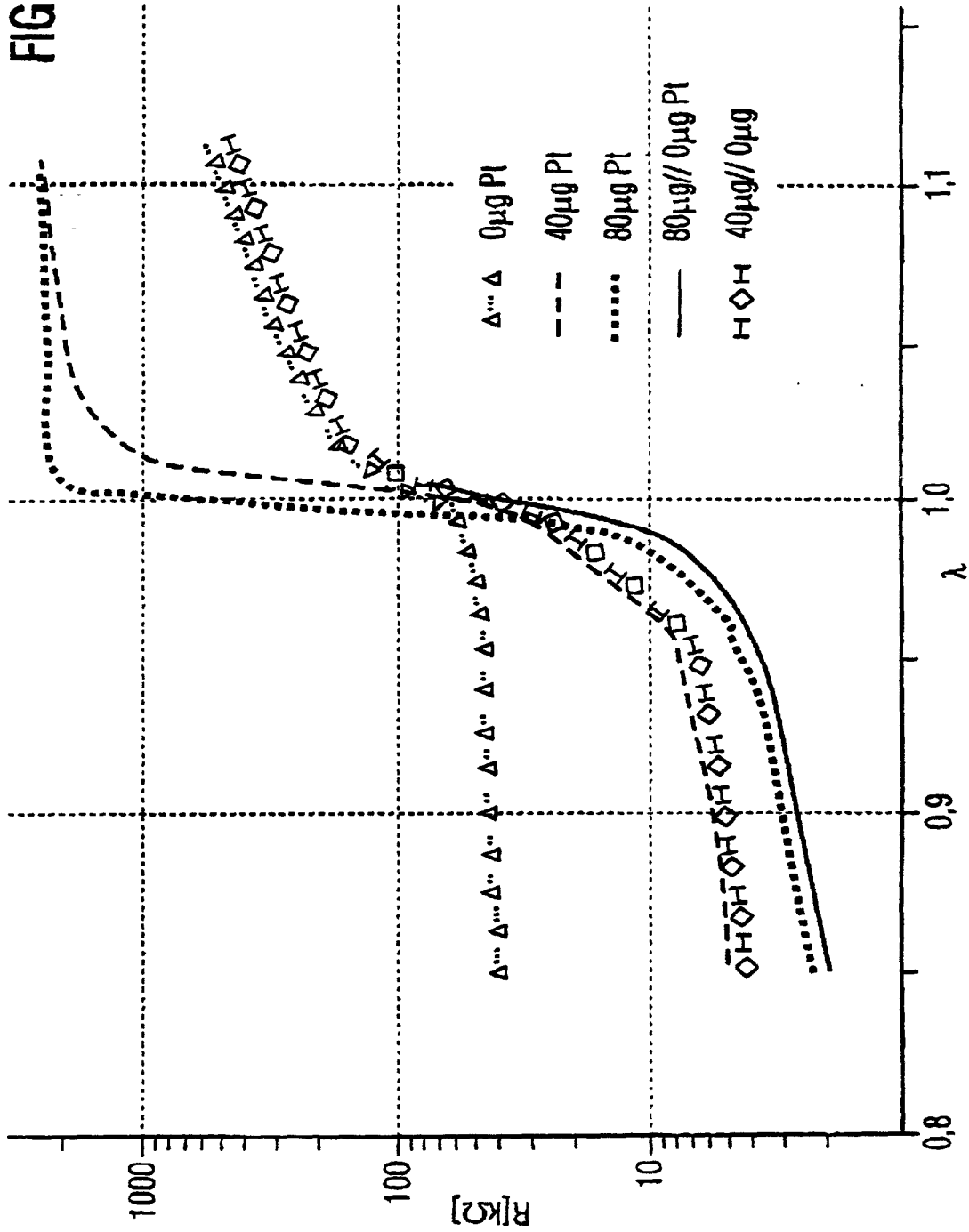


FIG 3



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**FIG 2**



# Declaration and Power of Attorney For Patent Application

## Erklärung Für Patentanmeldungen Mit Vollmacht

### German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt

As a below named inventor, I hereby declare that:

dass mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

My residence, post office address and citizenship are as stated below next to my name,

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I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

#### Gassensor und Verwendung

deren Beschreibung

(zutreffendes ankreuzen)

☒ hier beigelegt ist.

☐ am \_\_\_\_\_ als

PCT internationale Anmeldung

PCT Anwendungsnummer \_\_\_\_\_

eingereicht wurde und am \_\_\_\_\_

abgeändert wurde (falls tatsächlich abgeändert).

the specification of which

(check one)

☐ is attached hereto.

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PCT Application No. \_\_\_\_\_

and was amended on \_\_\_\_\_

(if applicable)

Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

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I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

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## German Language Declaration

Prior foreign applications  
Priorität beansprucht

Priority Claimed

198 18 474.3 Germany  
(Number) (Country)  
(Nummer) (Land)

24. April 1998  
(Day Month Year Filed)  
(Tag Monat Jahr eingereicht)

☒ ☐  
Yes No  
Ja Nein

(Number) (Country)  
(Nummer) (Land)

(Day Month Year Filed)  
(Tag Monat Jahr eingereicht)

☐ ☐  
Yes No  
Ja Nein

(Number) (Country)  
(Nummer) (Land)

(Day Month Year Filed)  
(Tag Monat Jahr eingereicht)

☐ ☐  
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(Application Serial No.)  
(Anmeldeseriennummer)

(Filing Date)  
(Anmeldedatum)

(Status)  
(patentiert, anhängig,  
aufgegeben)

(Status)  
(patented, pending,  
abandoned)

(Application Serial No.)  
(Anmeldeseriennummer)

(Filing Date)  
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Wohnsitz		Residence	
Staatsangehörigkeit		Citizenship	
Postanschrift		Post Office Address	

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